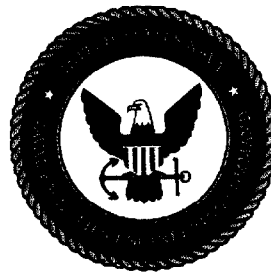


Final Work Plan  
Site Investigation at Point of Marsh BT-11  
(Sites I-32, 86, 87, 88 and 89)  
Marine Corps Air Station  
Cherry Point, North Carolina



Prepared for

**Department of the Navy**  
**Atlantic Division**  
**Naval Facilities Engineering Command**  
Norfolk, Virginia

Contract No. N62470-95-D-6007  
CTO-0126

July 1999

Prepared by

**CH2MHILL**

**Final**  
**Work Plan**  
**Site Investigation at Point of Marsh BT-11**  
**(Sites I-32, 86, 87, 88 and 89)**  
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# 1.0 Introduction

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This Work Plan describes the proposed Site Investigation (SI) activities to be conducted at Point of Marsh Bombing Target 11 (BT-11) Sites I-32, 87, 88 and 89, which are related to Marine Corps Air Station (MCAS) Cherry Point, North Carolina. For the purposes of this investigation, it is assumed that no field investigation or sampling activities will be required at BT-11 for Site 86.

The remainder of this Work Plan is divided into three sections, numbered 2 through 5. Section 2 is a description and site history of each of the component sites within BT-11. The site description and history was obtained from information provided by the Environmental Affairs Department (EAD) at MCAS Cherry Point, and from a site visit performed by CH2M HILL on April 14, 1999 that included an interview with Mr. Ken Daniels, an MCAS Cherry Point employee knowledgeable of the past activities conducted at BT-11. Section 3 is a description of the Site Investigation (SI) Work Plan that presents the proposed investigation activities, including the sampling objectives, strategy, field investigation procedures and overall approach; proposed sampling locations; analytical methods; and data quality assurance protocols. Section 4 is the Quality Assurance Project Plan (QAPP), which addresses project-specific quality assurance requirements. Finally, Section 5 lists the references cited in this document.

The description of the SI activities documented in Section 3 references master documents that detail most of the requirements and procedures to be employed in the execution of this Work Plan. The master documents include the *Master Quality Assurance Plan for Marine Corps Air Station, Cherry Point, North Carolina* (Brown & Root Environmental, April 1998a) and the *Master Field Sampling Plan for Marine Corps Air Station, Cherry Point, North Carolina* (Brown & Root Environmental, April 1998b).

## 2.0 BT-11 Site Description and History

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The information in this section was obtained from information provided by the EAD, MCAS Cherry Point and from a site visit to BT-11 conducted by CH2M HILL on April 14, 1999.

Point of Marsh BT-11 is located on Piney Island, east of MCAS Cherry Point (see Figure 2-1). Based on conversations with MCAS Cherry Point personnel, various areas of BT-11 are presently used by the Navy for aerial target practice purposes.

Access to Point of Marsh BT-11 from MCAS Cherry Point is via Route 70 to the east, followed by Route 12 to the North. Approximately one-half mile after turning onto Route 12, there is a government dock on the left, just before the Thorofare Bridge. From the dock, access to BT-11 is by boat via Thorofare Creek and along Long Bay. The boat lands at Point of Marsh at a dock near Building 9010.

According to facility personnel, most disposal activities at BT-11 occurred in the mid-1970's. Wastes disposed of at the various sites included stripped aircraft, aircraft parts, machinery, construction debris, batteries, glass and various paints, motor oil, detergents and solvents (including toluene and methyl ethyl ketone (MEK)). With respect to the disposal of solvents, facility personnel reported that cans of MEK and toluene were disposed of after allowing the materials to evaporate. A SI of five of these areas at BT-11 is now proposed, including:

- Site I-32 (Dump near Tower)
- Site 86 (Dump along shoreline adjacent to Building 9037)
- Site 87 (Dump ¼ mile NW of Building 9037)
- Site 88 (Dump on right corner of intersection of Main Road and Tower #3 Road)
- Site 89 (Dump at east end of Runway)

The site description and history of each component of BT-11 is presented individually in the following sections.

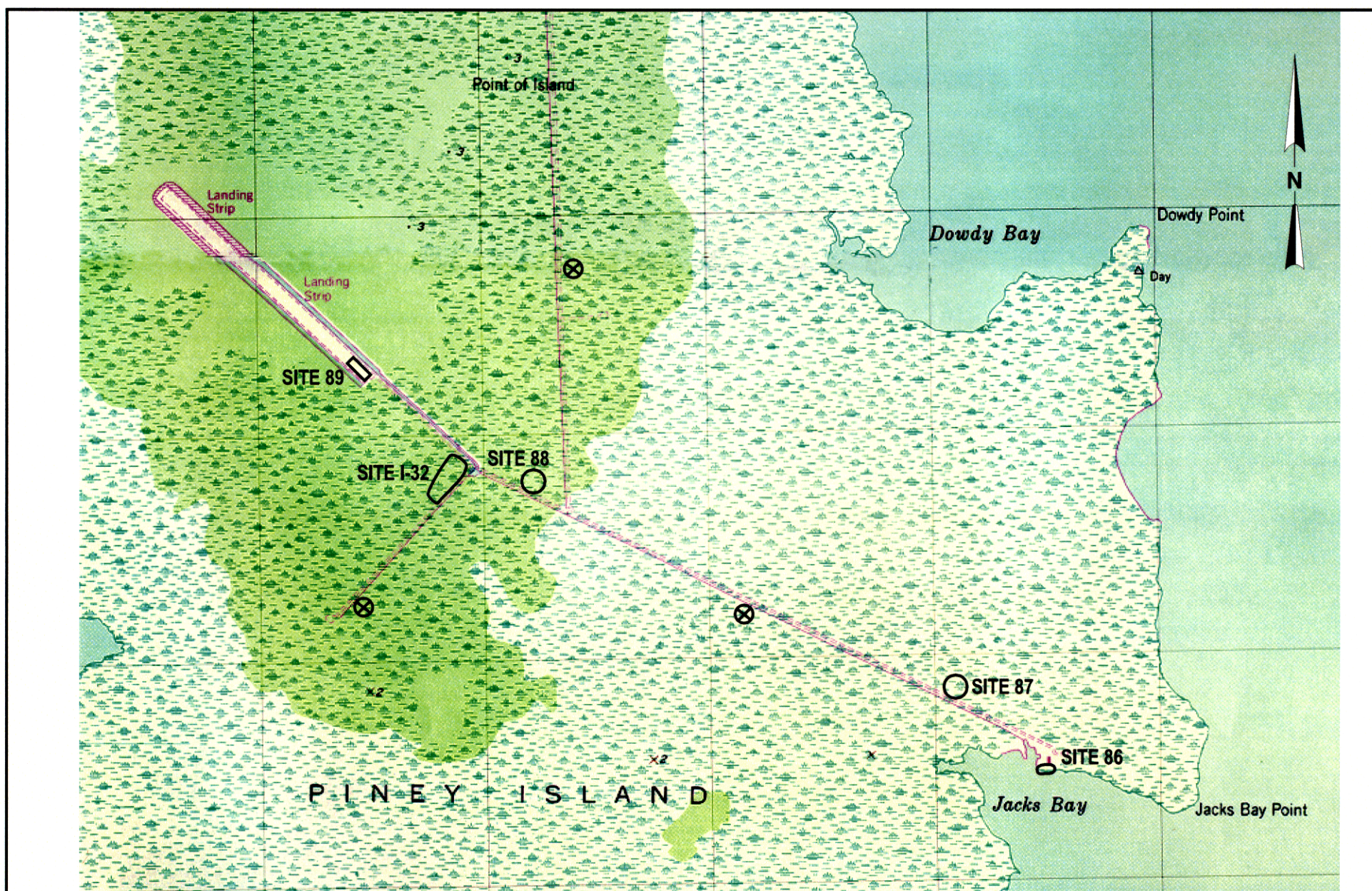
### 2.1 Site I-32 (Dump near Tower)

Site I-32 is located along the southwest side of the Main Road, near the intersection with a road running to the southwest perpendicular to the Main Road (see Figure 2-1). A tower is located adjacent to the site. The site is approximately 50' by 75' in area. Electric and sewer utilities are located opposite of Site I-32, across the graveled road perpendicular to the Main Road.

According to facility personnel, Site I-32 was previously used to dispose of numerous types of materials. Specifically, a hole was dug approximately 15 feet below ground surface, filled with waste, and covered with soil that was removed from the hole. According to facility personnel, the wastes disposed of at this site included detergents.

Presently, Site I-32 is no longer used for disposal purposes. During CH2M HILL's visit to Point of Marsh BT-11 in April 1999, waste material observed at the surface included several rusted drums, two batteries, fibrous material (non-asbestos) and glass debris.





SCALE 1:24 000

1 MILE

⊗ = Proposed background soil  
and groundwater sampling locations

Figure 2-1  
Site Location Map  
BT-11 Point of Marsh  
MCAS Cherry Point, NC

Source: Point of Marsh, NC and Long Bay, NC 7.5-minute USGS Quadrangle Maps

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## **2.2 Site 86 (Dump along shoreline adjacent to Building 9037)**

This site is located near Building 9037 on Piney Island. The site consists of the shoreline and bank near the docks. In the past, heavy concrete and steel material was deposited at Site 96 to stabilize the bank from erosion. The waste material includes steel parts of heavy machinery, concrete construction debris, and the empty steel casings of dummy bombs. According to facility personnel, no paints, solvents or trash were disposed of at Site 86.

## **2.3 Site 87 (Dump ¼ mile NW of Building 9037)**

Site 87 refers to a dump site located approximately ¼ mile to the northwest of Building 9037, on the northeast side of the Main Road (see Figure 2-2). This site is approximately 20' by 20' in area, and is predominately marshy, with the exception of the area adjacent to the Main Road.

According to facility personnel, Site 87 originated when a bulldozer attempted to excavate a pit for a dumpsite. Instead, the bulldozer sank into the marsh and had to be pulled out. The depression formed by the bulldozer was then used as a disposal pit. The waste materials reported to have been disposed of in this depression included batteries and motor oils.

## **2.4 Site 88 (Dump on right corner of intersection of Main Road and Tower #3 Road)**

Site 88 is located near a bridge, on the northwest corner of the intersection of the Main Road and Tower #3 Road. This site is approximately 30' by 30' in area.

In the past, Site 88 was used for surface disposal of numerous materials. EAD identified this site on October 8, 1997. During CH2M HILL's site visit in April 1999, only metal debris was observed at this site.

## **2.5 Site 89 (Dump at east end of Runway)**

Site 89 is located at the eastern end of the landing strip. This site is approximately 75' by 75' in area.

In general, this site was primarily used for the disposal of stripped aircraft and aircraft parts. On October 8, 1997, EAD reportedly observed two old fuel tanks and an old fuel truck at this site. During CH2M HILL's visit in April 1999, a number of shot-up aircraft and aircraft parts were observed in a depression at this site.

Fibrous material and a small amount of lead were also observed at Site 89. The lead appeared to have been originally poured on the ground in a molten state. Wood debris was also observed.

## 3.0 Site Investigation Work Plan

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This section outlines the specific activities proposed for the SI at BT-11. All field activities will be conducted in accordance with the Master FSP for MCAS Cherry Point (Brown and Root Environmental, April 1998b) unless stated otherwise in this project-specific Work Plan.

The analytical results of the sampling conducted during this SI will be evaluated to determine if a release has occurred at any of the investigated sites at BT-11 and to assess whether further investigation is warranted to characterize environmental conditions at each site.

### 3.1 Investigation Objectives

The specific objectives of this SI at Point of Marsh BT-11 are to determine if any releases of contamination have occurred and to determine if further investigation or characterization of contamination is warranted at Sites I-32, 87, 88 and 89. As will be discussed below, no investigation activities are proposed for Site 86.

The soil and groundwater analytical results of the field investigation will be compared to the most recent EPA Region III risk-based criteria as well as North Carolina Risk Analysis Framework Target Concentrations and 2L Groundwater Standards, as applicable. Based on these comparisons and a discussion of potential contaminant migration, potentially affected receptors, site-specific conditions and applicable clean-up levels, conclusions and recommendations will be made regarding the sites investigated.

The SI described in this Work Plan is intended to address potential contamination at the BT-11 sites. The site activities proposed as part of this Plan include advancement of soil borings, installation of temporary monitoring wells, and the collection of groundwater and soil samples. The remediation of soil and/or groundwater contamination at these four BT-11 sites and any performance monitoring or long-term monitoring associated with soil and/or groundwater remediation are not addressed in this Work Plan.

### 3.2 Proposed SI Activities

The following topics are discussed in this section: (1) mobilization/demobilization (2) soil borings and soil sampling; (3) installation of temporary monitoring wells and groundwater sampling; (4) data evaluation and review; (5) surveying; (6) IDW handling and disposal; (7) decontamination and (8) sample handling.

In general, for the BT-11 SI, the principal sampling technique to be used in the field will be a direct-push sampling tool operated by a subcontractor. Due to the necessity to access the BT-11 investigation sites by boat, an apparent depth to groundwater of zero to two feet below ground surface (bgs), and marshy conditions at some investigation

sites, it is anticipated that a direct-push unit mounted on a small all-terrain tractor or 4-wheel cycle will be used. Alternatively, a hand-operated direct-push sampling tool may be used in lieu of the vehicle-mounted tool at Site 87, where almost the entire site is marshy.

The direct-push tool(s) will be used to collect samples of subsurface soils using a coring tool, to collect groundwater samples using a driven groundwater sampling tool, and to install temporary monitoring wells. It is assumed that the maximum depth of soil and groundwater sampling and the installation of temporary monitoring wells will be eight feet bgs.

### **3.2.1 Mobilization/Demobilization**

Following approval of the final Work Plan, CH2M HILL will begin mobilization activities. Prior to mobilization, all field team members will review the appropriate master planning documents (including the Master FSP and Master QAP) along with the final Work Plan and site-specific Health and Safety Plan (HASP). In addition, a field team kickoff meeting will be held prior to mobilization to ensure that personnel are familiar with the scope of field activities and safety issues.

Field mobilization/demobilization will be performed in accordance with the Master FSP for MCAS Cherry Point. Mobilization/demobilization activities specific to the BT-11 SI include obtaining utility clearance for proposed soil borings and monitoring well installation locations with air station personnel, coordination with air station personnel and subcontractors, and preparation of field equipment.

### **3.2.2 Soil Borings and Soil Sampling**

As mentioned previously, a direct-push tool will be used to collect samples of subsurface soils using a coring tool. In general, one soil sample will be collected at each soil boring location, from the unsaturated zone (estimated to be 0-1 foot bgs). Where no unsaturated zone exists and marshy conditions prevail, a saturated surface sample (i.e., sediment sample) will be collected.

Due to the lack of fixed markers and structures on available maps that illustrate the sites under investigation, as well as various surface debris and/or unknown subsurface conditions (e.g. buried debris) that will be encountered in the field, the exact proposed sampling locations at each site have not been presented in Figure 2-2. However, the general locations and the rationale for selecting the proposed sampling locations are described below.

#### **Site I-32**

The boundaries of this site appear to be unclear and disjointed. Prior to soil sampling, field personnel will attempt to identify the limits of the dumpsite in conjunction with facility personnel familiar with previous site activities. Upon delineation of the site boundaries, soil samples will be collected from four locations (one sample per location) within the interior of the site, preferably near potentially contaminated areas based on a visual reconnaissance. The four locations will be selected to provide uniform coverage of the site.

The CH2M HILL field personnel will prepare a detailed sketch during field activities of apparent site boundaries, observed surface features, and sampling locations.

#### **Site 86**

Based on interviews with facility personnel and a visual inspection by CH2M HILL during the site visit, it appears that disposal activities at Site 86 were limited to heavy, inert objects that could provide bank stabilization and erosion protection along the shoreline near Building 9037. Facility personnel indicated that none of the types of waste materials disposed of at the other sites that would provide the potential for a contaminant release (paints, solvents, motor oils, batteries, etc.) were deposited at Site 86. As a result, no field investigation or sampling activities is proposed at Site 86.

#### **Site 87**

Soil samples will be collected from three locations (one sample per location), preferably distributed within the disposal area itself. The three locations will be selected to provide uniform coverage of the site.

The CH2M HILL field personnel will prepare a detailed sketch during field activities of apparent site boundaries, observed surface features, and sampling locations.

#### **Site 88**

Soil samples will be collected from three locations (one sample per location), preferably distributed within the disposal area itself. The three locations will be selected to provide uniform coverage of the site.

The CH2M HILL field personnel will prepare a detailed sketch during field activities of apparent site boundaries, observed surface features, and sampling locations.

#### **Site 89**

Soil samples will be collected from four locations within the disposal area (one sample per location) at this site. Specifically, the locations will be selected based on visual observations and biased towards areas where potential contamination exists. The four locations will be selected to provide uniform coverage of the site.

The CH2M HILL field personnel will prepare a detailed sketch during field activities of apparent site boundaries, observed surface features, and sampling locations.

#### **Background Soil Sampling**

Since BT-11 is not located within the main compound of MCAS Cherry Point, background soil samples collected at MCAS Cherry Point during previous investigations are not likely to be representative of background soil conditions at BT-11. In order to assess background conditions at BT-11, CH2M HILL proposes to collect three soil samples at BT-11 at locations far from the known disposal sites. The proposed sample locations are illustrated in Figure 2-1.

The analytical results of the background soil samples will be used to compare to the analytical results of the soil samples collected from the disposal areas.

Additional details of soil boring advancement and soil sampling procedures can be found in Sections 2.2.1, 2.3.3, 2.9.3, 2.9.4 and 2.9.5 of the Master FSP for MCAS Cherry Point.

All soil samples will be submitted to a fixed laboratory for the following analyses:

- VOCs by EPA Method 8260 (Note: an Encore® sampling tool will be used in the field and methanol or sodium bicarbonate sample preservation using EPA Method 5035 will be performed in the laboratory prior to analysis)
- Target compound list (TCL) SVOCs by EPA Method CLP OLM03.2
- TCL Pesticides/PCBs by EPA Method CLP OLM03.2
- Target analyte list (TAL) Metals, including Cyanide by EPA Method CLP ILM04.0 via Trace ICP (Cyanide and Mercury via ILM04.0)

Along with the soil samples, a number of quality analysis/quality control (QA/QC) soil samples (field duplicates, equipment blanks, field blanks, trip blanks and MS/MSD samples) will be collected to ensure sample integrity. A listing of these proposed QA/QC samples is provided in Section 4.0. The complete soil analytical protocol has been summarized in Table 3-1. All of the analytical data generated during the field program will be validated by an independent data validation subcontractor in accordance with EPA standard procedures.

### **3.2.3 Installation of Temporary Monitoring Wells and Groundwater Sampling**

The installation of temporary groundwater monitoring wells using a direct-push sampling tool is proposed in association with the SI field investigation at Sites I-32, 87, 88 and 89. Each of the temporary monitoring wells will be constructed in accordance with the monitoring well construction and installation procedures outlined in Section 2.4 of the MCAS Cherry Point Master Field Sampling Plan (FSP). However, specific to this Work Plan, small diameter (3/4-inch inner diameter (I.D.) temporary wells with 5-foot long screens containing pre-packed sand filter jackets will be installed to collect groundwater samples wherever the vehicle-mounted direct-push tool can access the sampling location. The temporary monitoring well screens will be installed to straddle the water table. Groundwater samples will be collected directly from a hand-operated direct-push sampling tool at Site 87 (where marshy conditions prevail) and any other sampling location not accessible to the vehicle-mounted tool.

Temporary monitoring well boring logs and well construction logs will be completed by the field geologist during each well installation. Details of monitoring well installation and groundwater sampling procedures can be found in Sections 2.4.2 and 2.9.1 of the Master FSP for MCAS Cherry Point.

As stated previously, due to the lack of fixed markers and structures on available maps that illustrate the four sites under investigation, the proposed sampling locations at each site have not been presented in Figure 2-2. However, the general locations and the rationale for selecting the proposed sampling locations are provided below.



## Site I-32

The boundaries of this site appear to be unclear and disjointed. Prior to temporary well installation, field personnel will attempt to identify the limits of the dumpsite in conjunction with facility personnel familiar with previous site activities. Upon delineation of the site boundaries, four temporary monitoring wells will be installed within the interior of the disposal area itself. The four locations will be selected to provide uniform coverage of the site.

The exact locations of the temporary monitoring wells will be recorded on a detailed sketch prepared by the CH2M HILL field personnel.

| Table 3-1<br>SI Sampling Analytical Protocol<br>Point of Marsh BT-11<br>MCAS Cherry Point |   |            |              |                     |
|---|---|------------|--------------|---------------------|
| Analysis  | Laboratory Analytical Method  | BT-11 Site | Soil Samples | Groundwater Samples |
| VOCs  | CLP Low-concentration OLC02.1 (aqueous)/SW-846/8260B (solid)                    | I-32       | 4            | 4                   |
|   |   | 87         | 3            | 1                   |
|   |   | 88         | 3            | 3                   |
|   |   | 89         | 4            | 4                   |
| SVOCs   | CLP Low-concentration OLC02.1 (aqueous)/CLP OLM03.2 (solid)                     | I-32       | 4            | 4                   |
|   |   | 87         | 3            | 1                   |
|   |   | 88         | 3            | 3                   |
|   |   | 89         | 4            | 4                   |
| PCBs  | CLP Low-concentration OLC02.1 (aqueous)/CLP OLM03.2 (solid)                     | I-32       | 4            | 4                   |
|   |   | 87         | 3            | 1                   |
|   |   | 88         | 3            | 3                   |
|   |   | 89         | 4            | 4                   |
| Pesticides  | CLP Low-concentration OLC02.1 (aqueous)/CLP OLM03.2 (solid)                     | I-32       | 4            | 4                   |
|   |   | 87         | 3            | 1                   |
|   |   | 88         | 3            | 3                   |
|   |   | 89         | 4            | 4                   |
| Metals  | CLP ILM04.0 via Trace ICP (Cyanide and Mercury via ILM04.0) (aqueous and solid) | I-32       | 4            | 4                   |
|   |   | 87         | 3            | 1                   |
|   |   | 88         | 3            | 3                   |
|   |   | 89         | 4            | 4                   |
| Notes:<br>Sample quantities listed do not include QA/QC samples                           |   |            |              |                     |

## Site 86

Based on interviews with facility personnel and a visual inspection by CH2M HILL during the site visit, it appears that disposal activities at Site 86 were limited to heavy, inert objects that could provide bank stabilization and erosion protection along the shoreline near Building 9037. Facility personnel indicated that none of the types of waste materials disposed of at the other sites that would provide the potential for a contaminant release (paints, solvents, motor oils, batteries, etc.) were deposited at Site 86. As a result, no field investigation or sampling activities is proposed at Site 86.

**Site 87**

Due to the small size of this site, groundwater samples will be collected from three evenly distributed locations immediately surrounding the site to assess groundwater quality entering and accessing the site. Due to the marshy nature of this site, only one temporary well will be installed along the boundary of the site bordered by the road. The two other groundwater samples will be collected directly from a hand-operated direct-push sampling tool, at locations coinciding with the corners of an imaginary equilateral triangle immediately surrounding the site.

The exact locations of the temporary monitoring wells will be recorded on a detailed sketch prepared by the CH2M HILL field personnel.

**Site 88**

Due to the small size of this site, three temporary monitoring wells will be installed evenly distributed along the perimeter of this site to assess groundwater quality entering and accessing the site. Based on field observations, if a nearby water body exists, at least one of these wells will be located along the perimeter directly between the water body and the site, and the other two wells will be placed accordingly such that they are evenly distributed along the perimeter.

The exact locations of the temporary monitoring wells will be recorded on a detailed sketch prepared by the CH2M HILL field personnel.

**Site 89**

A total of four temporary monitoring wells will be installed at Site 89. It is likely that the large amount of surface debris at this site will make it difficult to install wells within the interior of the site. Therefore, three temporary monitoring wells will be installed evenly distributed along the perimeter of this site to assess groundwater quality entering and accessing the site. Specifically, one of these wells will be located along the perimeter between the existing canal (southwest of the site) and the site, and one well will be located along the perimeter between the existing landing strip (northwest of the site) and the site. The remaining perimeter well will most likely be located to the east/southeast site boundary. A fourth temporary well will be placed at an accessible location within the interior of the site, preferably at a location biased towards the potential for contamination.

The exact locations of the temporary monitoring wells will be recorded on a detailed sketch prepared by the CH2M HILL field personnel.

Upon installation of the temporary monitoring wells, groundwater samples will be collected from all wells in accordance with Section 2.9.1 of the Master FSP for MCAS Cherry Point. Specifically, groundwater samples will be collected with the low-flow purging technique using a peristaltic pump, as outlined in the Master FSP. A more detailed description of certain aspects of the low-flow purging technique is contained in CH2M HILL's Standard Operating Procedure: "Minimal Aeration Groundwater Sampling Method for Geochemical Indicators of Intrinsic Bioremediation," which is attached as Appendix A.

Dissolved oxygen (DO), pH, specific conductance, temperature, oxidation/reduction potential, and turbidity will be measured in the field prior to each sample collection using the procedures described in the Master FSP. Samples will be collected as described above and labeled in accordance with the nomenclature procedures outlined in the Master FSP. Water level measurements will be collected from each temporary monitoring well prior to sampling.

All groundwater samples will be submitted to a fixed laboratory for the following analyses:

- TCL low-concentration VOCs by EPA Method CLP OLC02.1
- TCL low-concentration SVOCs by EPA Method CLP OLC02.1
- TCL low-concentration Pesticides/PCBs by EPA Method CLP OLC02.1
- Target analyte list (TAL) Metals, including Cyanide by EPA Method CLP ILM04.0 via Trace ICP (Cyanide and Mercury via ILM04.0)

The complete groundwater analytical protocol has been summarized in Table 3-1. The recommendations in Table 3-1 for low-concentration VOCs, low-concentration SVOCs and low-concentration pesticides/PCBs for aqueous analyses, as well as metals analyses by trace ICP are deviations from the Master QAP. The low-concentration organic analyses are recommended in order to provide lower detection limits. Similarly, the recommendation for trace ICP analysis is based on the ability of this analysis to achieve lower detection limits than non-trace ICP analysis for all of the analytes except calcium and sodium. In addition, the cost for trace ICP analysis and non-trace ICP analysis is approximately the same.

Along with the stated groundwater samples, a number of quality analysis/quality control (QA/QC) groundwater samples (field duplicates, equipment blanks, field blanks, trip blanks and MS/MSD samples) will be collected to ensure sample integrity. A listing of these proposed QA/QC samples is provided in Section 4.0. All of the analytical data generated during the field program will be validated by an independent data validation subcontractor in accordance with EPA standard procedures.

### **3.2.4 Data Evaluation and Review**

When the analytical data from the SI field activities have been received, data review and evaluation will begin. The results of the SI field investigation will be used to prepare the SI Report. The objective of the SI Report will be to determine if a release has occurred at any of the BT-11 sites, and to assess whether further investigation or characterization of contamination is warranted.

### **3.2.5 Surveying**

CH2M HILL will survey to the nearest one meter, the boundaries of the four sites, soil boring and temporary monitoring well locations, and any other relevant site markers for horizontal control using a portable Global Positioning System (GPS) unit. A Trimble Pro-XL GIS-grade GPS receiver, in conjunction with a Pro-Beacon navigation beacon receiver, will be used. The navigation beacon receiver enables the reception of the U.S.

Coast Guard broadcast of differential corrections and allows the GPS receiver to generate corrected positions in real time.

The survey coordinates will be used to properly locate the sampling locations in the MCAS Cherry Point GIS.

### **3.2.6 IDW Handling and Disposal**

This SI will not produce any investigation-derived waste (IDW) that must be contained for off-site disposal as hazardous waste. It is assumed that all disposable sampling equipment and personal protective equipment can be disposed of as ordinary trash. Any excess soils from the sampling activities will be returned to the borehole from which they were obtained. In addition, the minimal amount of groundwater purged during sampling activities (low-flow purging) and decontamination rinse water will be disposed of on the ground at the site.

### **3.2.7 Decontamination**

All equipment involved in field investigation activities will be decontaminated upon arrival at the site, between sampling or borehole locations, and at the conclusion of investigation activities. Details on procedures for decontamination can be found in Section 2.14 of the Master FSP for MCAS Cherry Point.

### **3.2.8 Sample Handling**

Sample handling includes the field-related considerations regarding field sample documentation, nomenclature, packaging, shipping and custody. Sample handling and custody procedures are described in Sections 2.10 and 2.11 respectively, of the Master FSP for MCAS Cherry Point and Section 4.0 of the Master QAP for MCAS Cherry Point

## 4.0 Quality Assurance Project Plan

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### 4.1 Introduction

This Quality Assurance Project Plan (QAPP) addresses the quality assurance/quality control (QA/QC) issues that are specific to the SI at BT-11. The QA/QC protocols used at MCAS Cherry Point are detailed in the Master Quality Assurance Plan (QAP) for MCAS Cherry Point (Brown and Root Environmental, April 1998a).

### 4.2 Management Organization and Responsibilities

Details of the Program Management at MCAS Cherry Point are included in Section 2.0 of the Master QAP for MCAS Cherry Point. Additional information specific to this project is provided below.

The Navy, working with MCAS Cherry Point, is the lead agency responsible for all environmental activities performed under CERCLA and RCRA at the Air Station. CH2M HILL is the Navy's contractor that will be responsible for performing this SI.

The key organizations and personnel are as follows:

- Navy Technical Representative (NTR):

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Additional details on organization and responsibilities are provided in Section 2.0 of the Master QAP for MCAS Cherry Point.

## 4.3 Data Quality Requirements

Section 3.0 of the Master QAP for MCAS Cherry Point describes the overall data quality requirements for MCAS Cherry Point. This section describes specific data quality requirements for the SI at BT-11.

### 4.3.1 Data Quality Objectives

The objectives of the SI at BT-11 are to establish a platform of current environmental data to:

- Determine if a release has occurred at the BT-11 sites investigated; and to
- Assess whether further investigation or characterization of contamination is warranted.

The SI at BT-11 includes the advancement of soil borings, the installation of temporary monitoring wells and the collection of groundwater. Table 4-1 lists the analytical methods that should be used for fixed laboratory analysis of environmental samples collected at the BT-11 sites.

As mentioned previously, the recommendations in Table 4-1 for low-concentration VOCs, low-concentration SVOCs and low-concentration pesticides/PCBs for aqueous analyses, as well as metals analyses by trace ICP are deviations from the Master QAP. The low-concentration organic analyses are recommended in order to provide lower detection limits. Similarly, the recommendation for trace ICP analysis is based on the ability of this analysis

to achieve lower detection limits than non-trace ICP analysis for all of the analytes except calcium and sodium. In addition, the cost for trace ICP analysis and non-trace ICP analysis is approximately the same.

Furthermore, with regard to VOCs analyses for soil, collection of soil samples using the Encore® sampler requires either methanol or sodium bicarbonate sample preservation by the laboratory prior to using EPA Method SW-846/8260B.

### **4.3.2 Field-Related Quality Control Samples**

In addition to regular calibration of field equipment and appropriate documentation, quality control (QC) samples will be collected or generated during environmental sampling activities. These QC samples include field duplicates, trip blanks, equipment rinseate blanks, matrix spike/matrix spike duplicates, and field blanks. The collection of QC samples will be limited to samples for fixed laboratory analyses.

The general type and collection frequency of QC samples is presented in Table 4-2. A summary of project-specific QC samples to be collected is provided in Section 4.5, Table 4-3. Details on field-related QC samples are provided in Section 3.3 of the Master QAP for MCAS Cherry Point.

## **4.4 Sample Custody and Shipment**

Sample custody and shipment procedures have been developed for the preparation, handling, storage, and shipping of collected samples. Samples will be processed and shipped in accordance with Section 4.0 of the Master QAP for MCAS Cherry Point.

## **4.5 Sample Analyses**

The information in this section varies from Section 5.0 of the Master QAP for MCAS Cherry Point, and is specific to this project. Samples collected for chemical analysis during this investigation will be analyzed using the analytical procedures identified in Table 4-1, which can be found in Section 4.3. Table 4-3 summarizes the number of samples to be collected for fixed laboratory analysis during this SI, including QC samples, organized by analytical parameter and sample media.

The specific analytical parameters, contract-required quantitation/detection limits (CRQL/CRDLs), for the TCL organics and TAL metals analyses for this investigation are provided in Table 4-4. The actual method/instrument detection limits (MDL/IDLs) are not listed since they may vary depending on the lab that performs the actual analyses.

## **4.6 Internal Quality Control Checks**

Field-related (i.e., external) QC checks are discussed in Section 3.0 of the Master QAP for MCAS Cherry Point and detailed in Section 4.3.2 and Table 4-3. Section 6.0 of the Master QAP details internal QC checks and other laboratory QA/QC considerations.

## **4.7 Project Records**

Project records are important to support the defensibility of collected data. Details regarding project records are included in Section 7.0 of the Master QAP for MCAS Cherry Point.

## **4.8 Data Reduction, Validation and Reporting**

Details regarding data reduction, validation and reporting procedures are provided in Section 8.0 of the Master QAP for MCAS Cherry Point.

## **4.9 Performance and System Audits**

Performance and system audits will be performed periodically to ensure that project work is being conducted in accordance with approved Project Plans and in an overall satisfactory manner. Audit procedures can be found in Section 9.0 of the Master QAP for MCAS Cherry Point.

## **4.10 Corrective Actions**

Details regarding corrective actions for field, laboratory, data evaluation and administrative activities are included in Section 10.0 of the Master QAP for MCAS Cherry Point.

## **4.11 Training**

Training will comply with the requirements detailed in Section 11.0 of the Master QAP for MCAS Cherry Point.

**Table 4-1**  
**Fixed Laboratory Analytical Methods**

| <b>Matrix</b> | <b>Parameter</b>  | <b>Analytical Method</b>  |
|---------------|---|---------------------------|
| Groundwater   | TCL Low-concentration Volatile Organic Compounds              | CLP OLC02.1               |
| Groundwater   | TCL Low-concentration Semi-volatile Organic Compounds (SVOCs) | CLP OLC02.1               |
| Groundwater   | TCL Low-concentration Pesticides/PCBs                         | CLP OLC02.1               |
| Groundwater   | TAL Metals  | CLP ILM04.0 via Trace ICP |
| Groundwater   | Cyanide and Mercury   | CLP ILM04.0               |
| Soil          | Volatile Organic Compounds                                    | SW-846/8260B              |
| Soil          | TCL Semi-volatile Organic Compounds (SVOCs)                   | CLP OLM03.2               |
| Soil          | TCL Pesticides/PCBs   | CLP OLM03.2               |
| Soil          | TAL Metals  | CLP ILM04.0 via Trace ICP |
| Soil          | Cyanide and Mercury   | CLP ILM04.0               |

**Table 4-2**  
**General Requirements for QC Sample Collection**

| <b>QC Samples</b>              | <b>QC specified collection frequency</b>   |
|--------------------------------|--|
| Field Duplicates               | One duplicate per 10 samples of similar matrix or one duplicate per day per sampling event, whichever is more frequent |
| Trip Blanks                    | One set of trip blanks per cooler containing samples collected for VOC analysis  |
| Equipment Rinseate Blanks      | One rinseate blank per day per matrix per sampling event   |
| Field Blanks                   | One per site per sampling event  |
| Matrix Spike/Duplicate Samples | One set per 20 samples of similar matrix   |



**Table 4-3**  
**Fixed Laboratory Samples**  
**Point of Marsh BT-11 Site Investigation**  
**MCAS Cherry Point, North Carolina**

| Parameter                  | Method                            | Sample Type | No. of Samples | Trip Blanks | Equipment Rinseate Blanks | Field Blanks | Field Duplicates | Matrix Spike/Duplicate | Total Number of Samples |
|----------------------------|-----------------------------------|-------------|----------------|-------------|---------------------------|--------------|------------------|------------------------|-------------------------|
| TCL Volatile Organics      | CLP Low-concentration OLC02.1     | Groundwater | 14             | 3           | 1                         | 1            | 1                | NA                     | 20                      |
| Volatile Organics          | SW846-8260B                       | Soil        | 17             | 2           | 1                         | 1            | 1                | 1                      | 23                      |
| TCL Semi-volatile Organics | CLP Low-concentration OLC02.1     | Groundwater | 14             | NA          | 1                         | NA           | 1                | NA                     | 16                      |
|                            | CLP OLM03.2                       | Soil        | 17             | NA          | 1                         | NA           | 1                | 1                      | 20                      |
| TCL Pesticides/PCBs        | CLP Low-concentration OLC02.1     | Groundwater | 14             | NA          | 1                         | NA           | 1                | NA                     | 16                      |
|                            | CLP OLM03.2                       | Soil        | 17             | NA          | 1                         | NA           | 1                | 1                      | 20                      |
| TAL Metals*                | CLP ILM04.0 via Trace ICP         | Groundwater | 14             | NA          | 1                         | NA           | 1                | 1                      | 17                      |
|                            | (Cyanide and Mercury via ILM04.0) | Soil        | 17             | NA          | 1                         | NA           | 1                | 1                      | 20                      |

**Notes:**

NA = Not Applicable

TCL = Target Compound List

TAL = Target Analyte List

Assumptions regarding rate of sample collection:

1. Three days are required to collect groundwater samples at BT-11
  2. Two days are required to collect soil samples at BT-11
- Thus, total estimated field days for sample collection = 5

Trip blanks – one per cooler containing VOC samples per day

Equipment Rinseate blanks – one per matrix per day

Field Blanks – one per site per sampling event

Field Duplicates – one per every ten samples per matrix/medium

Matrix Spike/Matrix Spike Duplicates – One per 20 samples per matrix (not required for aqueous low-concentration analyses by CLP OLC02.0)

\*Cyanide and Mercury are not via Trace ICP

**Table 4-4**  
**Analytical Parameters, Contract-Required Quantitation/Detection Limits (CRQL/CRDLs)**  
**Fixed Laboratory Analyses for TCL Organics and TAL Metals**  
**Point of Marsh BT-11 Site Investigation**  
**MCAS Cherry Point**

|  | Aqueous   | Soil      |
|--|-----------|-----------|
|  | CRQL/CRDL | CRQL/CRDL |
| Analytical Parameter   | µg/L      | mg/kg     |
| <b>TCL VOCs CLP SOW OLC02 (Aqueous), SW-846/8260B (Soil)</b> |           |           |
| 1,1,1-TRICHLOROETHANE  | 1         | 0.01      |
| 1,1,2,2-TETRACHLOROETHANE                                    | 1         | 0.01      |
| 1,1,2-TRICHLOROETHANE  | 1         | 0.01      |
| 1,1-DICHLOROETHANE   | 1         | 0.01      |
| 1,1-DICHLOROETHENE   | 1         | 0.01      |
| 1,2-DIBROMOETHANE (EDB)                                      | 1         | 0.01      |
| 1,2-DICHLOROETHANE   | 1         | 0.01      |
| 1,2-DICHLOROETHENE (TOTAL)                                   | NA        | 0.01      |
| 1,2-DICHLOROPROPANE  | 1         | 0.01      |
| 2-BUTANONE (MEK)   | 5         | 0.01      |
| 2-HEXANONE   | 5         | 0.01      |
| 4-METHYL-2-PENTANONE (MIBK)                                  | 5         | 0.01      |
| ACETONE  | 5         | 0.01      |
| BENZENE  | 1         | 0.01      |
| BROMODICHLOROMETHANE   | 1         | 0.01      |
| BROMOFORM  | 1         | 0.01      |
| BROMOMETHANE   | 1         | 0.01      |
| CARBON DISULFIDE   | 1         | 0.01      |
| CARBON TETRACHLORIDE   | 1         | 0.01      |
| CHLOROBENZENE  | 1         | 0.01      |
| CHLOROETHANE   | 1         | 0.01      |
| CHLOROFORM   | 1         | 0.01      |
| CHLOROMETHANE  | 1         | 0.01      |
| CIS-1,3-DICHLOROPROPENE                                      | 1         | 0.01      |
| DIBROMOCHLOROMETHANE   | 1         | 0.01      |
| ETHYLBENZENE   | 1         | 0.01      |
| METHYLENE CHLORIDE   | 2         | 0.01      |

**Table 4-4**  
**Analytical Parameters, Contract-Required Quantitation/Detection Limits (CRQL/CRDLs)**  
**Fixed Laboratory Analyses for TCL Organics and TAL Metals**  
**Point of Marsh BT-11 Site Investigation**  
**MCAS Cherry Point**

| Analytical Parameter  | Aqueous           | Soil               |
|---|-------------------|--------------------|
|   | CRQL/CRDL<br>µg/L | CRQL/CRDL<br>mg/kg |
| STYRENE   | 1                 | 0.01               |
| TETRACHLOROETHENE   | 1                 | 0.01               |
| TOLUENE   | 1                 | 0.01               |
| TRANS-1,3-DICHLOROPROPENE   | 1                 | 0.01               |
| TRICHLOROETHENE   | 1                 | 0.01               |
| VINYL CHLORIDE  | 1                 | 0.01               |
| XYLENES, TOTAL  | 1                 | 0.01               |
| <b>Additional TCL Compounds using Low Concentration TCL VOCs CLP SOW OLC02 (Aqueous only)</b> |                   |                    |
| 1,2-DICHLOROBENZENE   | 1                 | NA                 |
| 1,3-DICHLOROBENZENE   | 1                 | NA                 |
| 1,4-DICHLOROBENZENE   | 1                 | NA                 |
| 1,2,4-TRICHLOROBENZENE  | 1                 | NA                 |
| 1,2-DIBROMOETHANE   | 1                 | NA                 |
| 1,2-DIBROMO-3-CHLOROPROPANE   | 1                 | NA                 |
| BROMOCHLOROMETHANE  | 1                 | NA                 |
| cis-1,2-DICHLOROETHENE  | 1                 | NA                 |
| trans-1,2-DICHLOROETHENE  | 1                 | NA                 |
| <b>TCL SVOCs CLP SOW OLC02 (Aqueous), CLP SOW OLM03 (Soil)</b>                                |                   |                    |
| 1,2,4-TRICHLOROBENZENE  | NA                | 0.33               |
| 1,2-DICHLOROBENZENE (o-)  | NA                | 0.33               |
| 1,3-DICHLOROBENZENE (m-)  | NA                | 0.33               |
| 1,4-DICHLOROBENZENE (p-)  | NA                | 0.33               |
| 2,2'-OXYBIS(1-CHLOROPROPANE)  | 5                 | 0.33               |
| 2,4,5-TRICHLOROPHENOL   | 20                | 0.83               |
| 2,4,6-TRICHLOROPHENOL   | 5                 | 0.33               |
| 2,4-DICHLOROPHENOL  | 5                 | 0.33               |
| 2,4-DIMETHYLPHENOL  | 5                 | 0.33               |
| 2,4-DINITROPHENOL   | 20                | 0.83               |

**Table 4-4**  
**Analytical Parameters, Contract-Required Quantitation/Detection Limits (CRQL/CRDLs)**  
**Fixed Laboratory Analyses for TCL Organics and TAL Metals**  
**Point of Marsh BT-11 Site Investigation**  
**MCAS Cherry Point**

|                              | Aqueous   | Soil      |
|------------------------------|-----------|-----------|
|                              | CRQL/CRDL | CRQL/CRDL |
| Analytical Parameter         | µg/L      | mg/kg     |
| 2,4-DINITROTOLUENE           | 5         | 0.33      |
| 2,6-DINITROTOLUENE           | 5         | 0.33      |
| 2-CHLORONAPHTHALENE ("BETA") | 5         | 0.33      |
| 2-CHLOROPHENOL               | 5         | 0.33      |
| 2-METHYLNAPHTHALENE          | 5         | 0.33      |
| 2-METHYLPHENOL               | 5         | 0.33      |
| 2-NITROANILINE               | 20        | 0.83      |
| 2-NITROPHENOL                | 5         | 0.33      |
| 3,3'-DICHLOROBENZIDINE       | 5         | 0.33      |
| 3-NITROANILINE               | 20        | 0.83      |
| 4,6-DINITRO-2-METHYLPHENOL   | 20        | 0.83      |
| 4-BROMOPHENYL PHENYL ETHER   | 5         | 0.33      |
| 4-CHLORO-3-METHYLPHENOL      | 5         | 0.33      |
| 4-CHLOROANILINE              | 5         | 0.33      |
| 4-CHLOROPHENYL PHENYL ETHER  | 5         | 0.33      |
| 4-METHYLPHENOL               | 5         | 0.33      |
| 4-NITROANILINE               | 20        | 0.83      |
| 4-NITROPHENOL                | 20        | 0.83      |
| ACENAPHTHENE                 | 5         | 0.33      |
| ACENAPHTHYLENE               | 5         | 0.33      |
| ANTHRACENE                   | 5         | 0.33      |
| BENZO(A)ANTHRACENE           | 5         | 0.33      |
| BENZO(A)PYRENE               | 5         | 0.33      |
| BENZO(B)FLUORANTHENE         | 5         | 0.33      |
| BENZO(G,H,I)PERYLENE         | 5         | 0.33      |
| BENZO(K)FLUORANTHENE         | 5         | 0.33      |
| BIS(2-CHLOROETHOXY)METHANE   | 5         | 0.33      |
| BIS(2-CHLOROETHYL)ETHER      | 5         | 0.33      |

**Table 4-4**  
**Analytical Parameters, Contract-Required Quantitation/Detection Limits (CRQL/CRDLs)**  
**Fixed Laboratory Analyses for TCL Organics and TAL Metals**  
**Point of Marsh BT-11 Site Investigation**  
**MCAS Cherry Point**

| Analytical Parameter   | Aqueous           | Soil               |
|--|-------------------|--------------------|
|  | CRQL/CRDL<br>µg/L | CRQL/CRDL<br>mg/kg |
| BIS(2-ETHYLHEXYL)PHTHALATE   | 5                 | 0.33               |
| BUTYLBENZYL PHTHALATE  | 5                 | 0.33               |
| CARBAZOLE  | NA                | 0.33               |
| CHRYSENE   | 5                 | 0.33               |
| DI-N-BUTYL PHTHALATE ("DIBUTYL")   | 5                 | 0.33               |
| DI-N-OCTYL PHTHALATE   | 5                 | 0.33               |
| DIBENZO(A,H)ANTHRACENE   | 5                 | 0.33               |
| DIBENZOFURAN   | 5                 | 0.33               |
| DIETHYL PHTHALATE  | 5                 | 0.33               |
| DIMETHYL PHTHALATE   | 5                 | 0.33               |
| FLUORANTHENE   | 5                 | 0.33               |
| FLUORENE   | 5                 | 0.33               |
| HEXACHLOROBENZENE  | 5                 | 0.33               |
| HEXACHLOROBUTADIENE  | 5                 | 0.33               |
| HEXACHLOROCYCLOPENTADIENE  | 5                 | 0.33               |
| HEXACHLOROETHANE   | 5                 | 0.33               |
| INDENO(1,2,3-CD)PYRENE   | 5                 | 0.33               |
| ISOPHORONE   | 5                 | 0.33               |
| N-NITROSO DI-N-PROPYLAMINE   | 5                 | 0.33               |
| N-NITROSODIPHENYLAMINE   | 5                 | 0.33               |
| NAPHTHALENE  | 5                 | 0.33               |
| NITROBENZENE   | 5                 | 0.33               |
| PENTACHLOROPHENOL  | 20                | 0.83               |
| PHENANTHRENE   | 5                 | 0.33               |
| PHENOL   | 5                 | 0.33               |
| PYRENE   | 5                 | 0.33               |
| <b>TCL Pesticides/PCBs CLP SOW OLC02 (Aqueous), CLP SOW OLM03.1 (Soil)</b> |                   |                    |
| 4,4'-DDD   | 0.02              | 0.0033             |



**Table 4-4**  
**Analytical Parameters, Contract-Required Quantitation/Detection Limits (CRQL/CRDLs)**  
**Fixed Laboratory Analyses for TCL Organics and TAL Metals**  
**Point of Marsh BT-11 Site Investigation**  
**MCAS Cherry Point**

|                       | Aqueous   | Soil      |
|-----------------------|-----------|-----------|
|                       | CRQL/CRDL | CRQL/CRDL |
| Analytical Parameter  | µg/L      | mg/kg     |
| 4,4'-DDE              | 0.02      | 0.0033    |
| 4,4'-DDT              | 0.02      | 0.0033    |
| ALDRIN                | 0.01      | 0.0017    |
| ALPHA-BHC (ALPHA-HCH) | 0.01      | 0.0017    |
| ALPHA-CHLORDANE       | 0.01      | 0.0017    |
| AROCLOR-1016          | 0.2       | 0.033     |
| AROCLOR-1221          | 0.4       | 0.067     |
| AROCLOR-1232          | 0.2       | 0.033     |
| AROCLOR-1242          | 0.2       | 0.033     |
| AROCLOR-1248          | 0.2       | 0.033     |
| AROCLOR-1254          | 0.2       | 0.033     |
| AROCLOR-1260          | 0.2       | 0.033     |
| BETA-BHC (BETA-HCH)   | 0.01      | 0.0017    |
| DELTA-BHC (DELTA-HCH) | 0.01      | 0.0017    |
| DIELDRIN              | 0.02      | 0.033     |
| ENDOSULFAN I          | 0.01      | 0.0017    |
| ENDOSULFAN II         | 0.02      | 0.0033    |
| ENDOSULFAN SULFATE    | 0.02      | 0.0033    |
| ENDRIN                | 0.02      | 0.0033    |
| ENDRIN ALDEHYDE       | 0.02      | 0.0033    |
| ENDRIN KETONE         | 0.02      | 0.0033    |
| GAMMA-BHC (LINDANE)   | 0.01      | 0.0017    |
| GAMMA-CHLORDANE       | 0.01      | 0.0017    |
| HEPTACHLOR            | 0.01      | 0.0017    |
| HEPTACHLOR EPOXIDE    | 0.01      | 0.0017    |
| METHOXYCHLOR          | 0.1       | 0.017     |
| TOXAPHENE             | 1         | 0.17      |

**Table 4-4**  
**Analytical Parameters, Contract-Required Quantitation/Detection Limits (CRQL/CRDLs)**  
**Fixed Laboratory Analyses for TCL Organics and TAL Metals**  
**Point of Marsh BT-11 Site Investigation**  
**MCAS Cherry Point**

|                                   | Aqueous   | Soil      |
|-----------------------------------|-----------|-----------|
|                                   | CRQL/CRDL | CRQL/CRDL |
| Analytical Parameter              | µg/L      | mg/kg     |
| <b>TAL Metals CLP SOW ILM04.0</b> |           |           |
| ALUMINUM                          | 200       | 40        |
| ANTIMONY                          | 60        | 12        |
| ARSENIC                           | 10        | 2         |
| BARIUM                            | 200       | 40        |
| BERYLLIUM                         | 5         | 1         |
| CADMIUM                           | 5         | 1         |
| CALCIUM                           | 5000      | 1000      |
| CHROMIUM                          | 10        | 2         |
| COBALT                            | 50        | 10        |
| COPPER                            | 25        | 5         |
| CYANIDE                           | 10        | 5         |
| IRON                              | 100       | 20        |
| LEAD                              | 3         | 0.6       |
| MAGNESIUM                         | 5000      | 1000      |
| MANGANESE                         | 15        | 3         |
| MERCURY (INORGANIC)               | 0.2       | 0.1       |
| NICKEL                            | 40        | 8         |
| POTASSIUM                         | 5000      | 1000      |
| SELENIUM                          | 5         | 1         |
| SILVER                            | 10        | 2         |
| SODIUM                            | 5000      | 1000      |
| THALLIUM                          | 10        | 2         |
| VANADIUM                          | 50        | 10        |
| ZINC                              | 20        | 4         |

## 5.0 References

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Brown & Root Environmental (April 1988a), *Master Field Sampling Plan for Marine Corps Air Station Cherry Point, North Carolina*, Contract Number N62472-90-D-1298, Contract Task Order 0266.

Brown & Root Environmental (April 1998b), *Master Quality Assurance Plan for Marine Corps Air Station Cherry Point, North Carolina*, Contract Number N62472-90-D-1298, Contract Task Order 0266.

## **Appendix A**

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## APPENDIX A

# Standard Operation Procedure Minimal Aeration Groundwater Sampling Method for Geochemical Indicators of Intrinsic Bioremediation

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## Introduction

This document presents a protocol for measurements and groundwater sampling in support of intrinsic bioremediation characterizations. This protocol was developed because of the potential adverse effects of commonly employed groundwater sampling methodology on the quality of intrinsic bioremediation data.

Naturally occurring contaminant biodegradation can result in groundwater that is in dramatic non-equilibrium with the atmosphere. Commonly employed sampling collection techniques include use of bailers and excessive rates of groundwater purging. These practices may result in exposure of the groundwater to the atmosphere and will often produce groundwater samples with a geochemistry that is different than formation groundwater. Parameters for characterization of intrinsic bioremediation are listed in Table A-1. The potential adverse effects of groundwater sampling technique on data quality for select intrinsic bioremediation parameters are summarized in Table A-2. The specific mechanisms in which the geochemistry of groundwater samples can be altered through sample collection techniques include the following:

- Excessively lowering the water level in the well by purging at high flow rates. During recharge, water trickling into the well may be exposed to the atmosphere, resulting in artificial aeration of the groundwater sample, which can cause loss of volatiles, introduction of oxygen, and elevation of the sample Eh.
- Sample aeration caused by sample collection with a bailer and/or excessive exposure of the groundwater to the atmosphere during field measurements or filling of sample containers.
- Increased turbidity caused by bailing the well, or purging the well at high flow rates creating high entrance velocities through the well screen and mobilizing sediment in the well, sand pack, and formation.
- De-pressurization of samples of deep groundwater can result in super-saturation of the groundwater with certain constituents and de-gassing of the constituents from the sample. (However, this should not be a significant problem at LNAPL sites, where the groundwater zone of interest is typically the uppermost saturated interval.)

**Table A-1**  
**Intrinsic Bioremediation Groundwater Characterization<sup>a</sup>**

| Parameter                              | Objective  | Method   |
|--|--|--|
| Dissolved oxygen                       | Preferred electron acceptor  | <b>SM4500-O.G (Membrane electrode)</b> and/or HACH Winkler Field test kit (Azide modified Winkler) |
| Nitrate                                | Electron acceptor  | <b>SM4110/EPA 300</b> or SM 4500-NO <sub>3</sub> -C  |
| Sulfate                                | Electron acceptor  | <b>SM4110/EPA300</b> or SM 4500-SO <sub>4</sub> -E   |
| Ferrous iron (Fe <sup>2+</sup> )       | Produced when ferric iron is the electron acceptor                                 | <b>SM 3120B/EPA 200.7</b> or SM 3500-Fe-D  |
| Methane/Carbon Dioxide                 | Produced when carbon dioxide or acetate is the electron acceptor                   | <b>R.S. Kerr 175</b> (Kampbell <i>et al.</i> , 1989)   |
| Alkalinity (Carbonate and bicarbonate) | Indicators of contaminant mineralization   | <b>SM 2320.B</b>   |
| Oxidation/reduction potential (ORP)    | Confirmation of general redox state as determined from electron acceptor chemistry | Field measurement <b>SM 2580-B</b>   |
| pH, electrical conductance             | Standard water quality parameters. Determination of pH especially important        | Field Instruments <b>SM 4500-H-B</b>   |
| Temperature                            | Standard water quality parameter   | Field measurement <b>SM 2550.B</b>   |

Preferred method is in bold typeface.

<sup>a</sup> This list is the "typical minimum" for characterizing site groundwater geochemistry to support evaluations of intrinsic bioremediation. Refer to other protocols and guidance documents to determine the complete suite of parameters that best meets the project needs.

SM – Standard Methods for the Examination of Water and Wastewater, 18th Edition, Greenberg, *et al.*, 1992.

**Table A-2**  
**Potential Effects of Sampling Protocol on Select Intrinsic Bioremediation Parameters**

| Parameter                          | Artificial Aeration   | Turbidity  |
|------------------------------------|---|--|
| Oxidation/reduction potential (Eh) | Introduction of oxygen raises Eh through oxidation of reduced species.      | Solids in bottom of well may be at different geochemical state than formation; introduction of these solids in groundwater may alter Eh in resulting groundwater sample. |
| Dissolved oxygen                   | May increase D.O. of sample.  | May lower D.O. of sample through oxygen demand exerted by geochemically reduced solids.  |
| Nitrate                            | ----  | Nitrate may be lowered through electron acceptor demand exerted by geochemically reduced species associated with solids.   |
| Sulfate                            | ----  | Analysis may yield sulfate concentration greater than in formation groundwater because of sulfate associated with solids.  |
| Iron                               | Oxidation/precipitation of iron may decrease concentration of ferrous iron. | Analysis may yield iron concentration greater than in formation groundwater because of iron associated with solids.  |
| Methane                            | May reduce concentration through loss to the atmosphere.                    | Turbidity not likely to affect methane concentration.  |

Note: Turbidity may also adversely impact field measurements based on colorimetric methods.



The “minimal aeration method” described in this protocol will enable collection of representative groundwater samples for characterization of intrinsic bioremediation, except at sites of very low permeability. Considerations for very low permeability settings are discussed.

## **Standard Operating Procedure**

The minimal aeration method described herein has been adapted from the protocols specified by EPA in their most recent groundwater monitoring guidance (EPA, 1992), demonstrated by Barcelona for providing consistent monitoring results for volatile constituents (Barcelona *et al.*, 1994), and discussed in a recent EPA technical support document (Puls and Barcelona, 1996). The method is described below.

## **Equipment Requirements**

Equipment needed for sample collection is provided in the attached checklist (Attachment A).

## **General Pre-Sampling Procedure**

Prior to purging and groundwater sampling, the routine procedures listed in the attached checklist (Attachment B) should be conducted.

## **Monitoring Well Purging**

The objective of purging the monitoring well is to collect groundwater samples representative of the formation groundwater. At most petroleum hydrocarbon sites, the groundwater near the water table surface will have the highest constituent concentrations, and monitoring wells are therefore screened across the water table. In these wells, the pump intake should be placed approximately 1 foot below the water level. If the well has a discrete screen length that is entirely submerged, the pump intake should be placed within the screened interval.

To collect intrinsic bioremediation parameter samples, monitoring wells should be purged at a rate that does not lower the water level significantly (i.e., less than 10 percent of the screen length). The specific pumping rate that will not cause excessive drawdown is dependent on the size of the well, permeability of the formation, etc. Check previous purge records for insight into the proper rate. When this information is not available, start with a flow rate of approximately 0.5 L/min and check the water level response in the well, increasing or decreasing the rate accordingly. The purging rate should be controlled as needed using the pump's variable speed flow controller and/or the gate valve in the discharge line. Collect water level measurements frequently during purging to ensure that the water level has not dropped lower than desired (see the attached sampling form). Monitoring wells should be purged until the field parameters have stabilized to within the ranges presented in Table 3. If an electric submersible pump is used, temperature may slightly increase rather than stabilize during low flow rate purging.

The method described above is recommended as an alternative to the conventional “three well volume” purging protocol. Purging until the parameters in Table A-3 have stabilized is a technically sound method for obtaining groundwater samples that are representative of



formation groundwater. Most regulatory agencies accept this newer method based on its technical merits. However, some regulatory agencies may still require the older "three well volume" method. For wells completed in very transmissive zones, it may not be practical to purge at a slow rate with minimal water table depression while still achieving the required purge volume. In these cases, a higher purge rate may be acceptable initially, but purging rates should be decreased as the required purge volume is approached, with the objective of producing groundwater samples that are not turbid and have not been artificially aerated.

As a cost control measure, it may be appropriate to terminate purging and collect the sample at pre-determined, arbitrary endpoints (e.g., after 3 well volumes, after one hour of purging, etc.), regardless of whether or not the criteria in Table A-3 have been achieved.

### Field Indicator Parameter Measurement

During purging, continuously measure dissolved oxygen, electrical conductance, pH, Eh, and temperature with the flow cell or equivalent arrangement (e.g., discharge line from pump to small beaker in which the probes are immersed). Flow cells are commercially available from a number of vendors including QED, Hydrolab, and YSI. If using the beaker arrangement for measuring the field indicator parameters, direct the discharge into the bottom of the beaker and allow the beaker to continuously overflow during measurements to minimize aeration. Allowing the discharge to pour into the container will artificially aerate the water, thus altering the properties of the water with respect to key parameters such as dissolved oxygen and oxidation-reduction potential.

Record indicator parameter and water level measurements in a field notebook or onto well development logs every three to five minutes or at a minimum frequency of approximately 1/4 well volume increments (see the attached sampling form). Purging is complete once the parameters have stabilized to within the ranges presented in Table A-3 regardless of the number of well volumes purged.

| Table A-3<br>Criteria for Stabilization of Indicator Parameters During Purging |  |
|--|--|
| Field Parameter  | Stabilization Criterion                          |
| Dissolved Oxygen   | 0.10 mg/L or 10% of value (whichever is greater) |
| Electrical Conductivity  | 3% Full Scale Range                              |
| pH   | 0.10 pH unit                                     |
| Temperature  | 0.2° C   |

If using the electric submersible pump (i.e., Redi-Flo 2) care must be taken to prevent flow interruption. If the flow is interrupted for any reason (e.g., loss of power), entry of air into the tubing usually occurs, with the potential result of artificially aerating the groundwater

sample. In addition, restarting the pump may cause a surge in flow that will suspend particulate matter in the well.

## **Groundwater Sample Collection**

When purging is complete, collect aliquots for the analytical parameters listed in Table A-1. To ensure the most consistent, comparable results, individual samples/measurements from all wells should be collected in the same order. The order used in this protocol is based on the approximate order of susceptibility to artificial aeration: volatile organics, total organic carbon (TOC), methane, iron, alkalinity, and sulfate.

Reduce the pumping rate and/or use the 3-way valve to collect the methane, volatile organics and TOC samples. Direct the discharge toward the bottom, inside wall of the jar to minimize volatilization, and fill to overflowing. Filter the discharge prior to filling the ferrous iron sample jar using an in-line 0.45-micron filter. Filtration is recommended to eliminate bias introduced with particulates. In-line filtration is recommended to prevent artificial aeration of the sample.

If additional samples are collected for dissolved oxygen analysis using field kits (i.e. Hach or Winkler), submerge the sample jar into the bottom of the large container, continue to fill the container to overflowing, and allow the sample jar to fill without aeration.

Preserve and analyze the samples as described in the sampling and analysis plan.

## **Quality Control Check for Field Measurements**

Field checks should be performed to ensure that representative measurements are being made. At a minimum, Eh and D.O. readings should be in agreement. D.O. readings should be less than one when the Eh is negative. If this is not the case, one or the other measurement is in error. When additional geochemical parameters are measured in the field, additional checks can be made. For example, ferrous iron should be present in elevated concentrations only when D.O. is less than one and the Eh is negative. When all measurements are not in agreement, measurements should be repeated until agreement is reached. In this process of achieving consistent results, there may be merit in trying alternative measurement techniques; for example, use of a Hach field kit for D.O. rather than a D.O. measurement probe.

Another check for representative results can be made by comparing the D.O. and Eh of well water before and after purging. In almost all cases, the D.O./Eh measurements taken from the well water prior to purging should be equal to or higher than the D.O./Eh of the formation groundwater. Increase in the D.O. and Eh as a result of purging is an indication of artificial aeration of the water.

In many cases, generation of valid field measurements for these parameters is not a trivial matter. Consideration should be given to including an analytical chemist on the field sampling crew. If this is not practical, the field crew should have familiarity with the problems that may arise in obtaining valid measurements and/or have access to an analytical chemist during the sampling effort to assist in resolution of measurement difficulties and apparent anomalies.

## Tips and Recommendations

Following are tips that will facilitate implementation of the minimal aeration method and improve the representativeness of data collected.

- Dedicated pumps are recommended by many investigators (Kearl, *et al.*, 1994), (Barcelona, *et al.*, 1994), and (Kearl, *et al.* 1992) to reduce data quality variations due to inconsistent sampling technique, avoid cross contamination from sampling equipment, save time during sampling events, and reduce the overall cost of sampling.
- Wells should be thoroughly developed when installed at pumping rates greater than anticipated purging and sampling rates to eliminate or minimize production of sediment and colloidal particulates.
- Determine the depth of the well from well construction logs. Measuring the depth to the bottom of the well will cause suspension of settled solids and mixing of water within the well, thus requiring longer purge times. If well depth measurements are desired, perform the measurements after sampling is completed.
- Lower the pump slowly into the well to minimize surging the water column. Have the pump tubing measured and marked off before placing it down the well so you know where exactly to place the pump intake (i.e., one foot below water level or a minimum of one foot below the top of screen, whichever is lower).
- If using a submersible electric pump, use a generator that will allow the pump to run smoothly. Usually, a generator with 10 amps or greater of power and an automatic throttle (i.e., Honda 3500) works well.
- Do not start the pump too quickly. This may create a surge of water flow and cause unwanted turbidity in the sample. On the same note, make sure that you have a check valve on the pump tubing. If the pump shuts off accidentally, the check valve will prevent water in the tubing from rushing back into the well causing the groundwater to be aerated.
- Select a pump setting low enough that it will not break suction and stop pumping. Check any previous records on the purge rates vs. drawdown in the well. It is helpful to have some prior knowledge about the well's recharge rate and drawdown, so that stopping the pump, and/or lowering the pump are avoided. Periodically measure the water level in the well to prevent pump shutdown or drawdown that is too far down the well screen.
- Record data regarding the well's purge rate and drawdown for the next sampling event.
- Use tubing with as small a diameter as possible. If the submersible pump requires larger tubing, use a reducer to minimize the diameter of the tubing. Small diameter tubing will reduce the chance of aeration within the tubing and improve the responsiveness of flow cell measurements (see the following bullet).
- Minimize the volume of water within the tubing and flow cell or beaker in which probe measurements are made. A large volume of water up-stream of the monitoring point

(i.e. probe location) increases the amount of time required for steady-state conditions in the well to manifest themselves at the monitoring point. Flow cells or measurement beakers with a large volume and residence time are particularly problematic, due to the dilution effects and the longer time required to achieve a steady-state reading at the measurement point. Small diameter flow cells that most closely achieve plug flow are preferred. If using a beaker set-up, try to ensure flow from the discharge tubing directly across the probes.

- Be careful of air bubbles trapped in the pump tubing. To minimize bubbles, hold the end of the groundwater discharge tubing vertical and higher than any other point in the tubing. It is also helpful to tap the tubing lightly to force bubbles to rise to the end of the tubing. It is important to minimize air bubbles because they could potentially aerate the groundwater sample.
- A three-way valve or tee with valves on two legs is recommended so that the pump rate is not altered and a constant flow rate can be maintained while sampling. The valve is configured so that one leg is connected to the discharge tubing and one leg flows into the flow-cell; the third is turned on only when filling sample bottles.

## Considerations for Very Low Permeability Settings

Monitoring wells screened across very low permeability materials (silts, clays, etc.) typically purge dry and are then allowed to recharge prior to sampling. However, recharge into a dewatered well results in increased exposure of the water entering the well to the air present at the water table interface and in the well, potentially altering the groundwater geochemistry as summarized in Table 2. To attempt to minimize these effects, the pump intake should be placed 2-3 feet below the water level and operated at as low a rate as is achievable, ideally equal to the recovery rate. In this manner, water drawn into the pump would be primarily from the formation and sand pack pore spaces. Close monitoring of the indicator parameter measurements is necessary since stabilization should occur prior to one borehole volume.

In some cases, a well may recharge so slowly that it may be impractical or even impossible to collect a groundwater sample that is truly representative of formation groundwater with respect to key geochemical parameters. If there is a need to collect samples/measurements for intrinsic bioremediation parameters in such cases, slowly purge the well dry and collect the groundwater samples as soon as the necessary volume has recharged into the well. As previously described in Section 2.6, the D.O. and Eh should be measured prior to, during, and after purging. An increase in D.O. or Eh is an indication of artificial aeration of the water, and results should be qualified accordingly.

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| Attachment A: Equipment Checklist |   |
|-----------------------------------|---|
|                                   | Monitoring well construction details (geologic log, screened interval, well depth, bore-hole diameter, etc.).                                 |
|                                   | Water level indicator   |
|                                   | Submersible positive displacement pump and controller or bladder pump (e.g. Grundfos Redi-Flo, QED Well Wizard, etc.)                         |
|                                   | Fluoroethylene polymer (FEP) tubing in sufficient quantity to use new tubing for each well. Note: Teflon is quite permeable to certain gases. |
|                                   | Throttling valves and 3-way flow-tee sampling valve (See Figure 1)  |
|                                   | Field meters for pH, Eh, dissolved oxygen, temperature, electrical conductance (including instrument manuals and calibration materials)       |
|                                   | Calibrated bucket or beaker to measure flow rate  |
|                                   | Flow cell with ports for each of the field meter probes (optional).   |
|                                   | Field note book and/or well purging log forms   |
|                                   | Sample containers, preservatives, ice and cooler(s)   |
|                                   | Decontamination supplies  |
|                                   | Personal protective equipment   |

### Attachment B: Pre-Purging Checklist

|  |   |
|--|---|
|  | Decontaminate submersible pump (if not a dedicated pump).   |
|  | Decontaminate or replace discharge tubing (if not a dedicated pump).  |
|  | Calibrate field meters (pH, Eh, specific conductance, dissolved oxygen, HNu, etc.) If possible, perform two point calibration on DO meter.  |
|  | Decontaminate water level indicator probe and tape.   |
|  | Unlock the monitoring well and measure vapor concentrations in accordance with the site specific Health and Safety Plan.  |
|  | Measure depth to water.   |
|  | Evaluate whether water table surface is above or within the screened interval.  |
|  | Calculate the volume of water in the well and borehole filter sand pack pore space (borehole volume).   |
|  | Insert dissolved oxygen probe into the monitoring well and measure the dissolved oxygen in the water column. If practical, also measure Eh of water in well.  |
|  | Install submersible pump into the well slowly to minimize aeration, placing the pump intake within the screened interval or approximately 1 foot below the water level.                                 |
|  | If gasoline or diesel powered generators or compressors are used to operate the pump, take precautions to prevent the exhaust from contaminating the samples.   |
|  | Configure the discharge tubing with a gate valve and 3-way valve, with discharge directed through the 3-way valve and flow cell (optional), and into a calibrated decontaminated bucket (See Figure 1). |